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(54) IMPROVEMENTS IN OR RELATING TO GAS SUPPLYING APPARATUS

(71) We ALBERT HOFFMANN, a German citizen, of 61 Untenende, 2953 Westrhauderfehn, Germany, and HANS SPECHTMEYER, a German citizen, of 28 Ulrichstrasse, 295 Leer, Germany, assignee of EMIL UECKER), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an apparatus for supplying gas. Apparatus is known of the kind in which the gas, e.g. oxygen, under pressure in the interior of a pressure bottle flows out after a shut-off valve has been opened through a pressure reducing system arranged in the bottle. The apparatus serves to supply for example sick persons or casualties with oxygen or can be used to supply rooms with oxygen.

In such apparatus of the above kind the pressure reducing system comprises a capillary tube which is provided with bends and connected upstream of the shut-off valve.

The effect of the pressure drop in the capillary tube is based on the principle of the Hagen-Poiseuille law which states that, in a laminar flow, the length of the capillary tube is directly proportional to the pressure drop. The resistance of the capillary tube is increased to a very considerable extent by turbulence which occurs at high gas velocities. The associated vibration subjects a joint between the capillary tube and the shut-off valve to mechanical stress. The alteration in the structure of the material resulting from the considerable drop in temperature, in addition to the vibration, readily leads to the failure of the known apparatus. Consequently, the capillary tube cannot be fitted in an oxygen bottle of large volume, or cannot be used in a system having coupled oxygen bottles.

The present invention provides apparatus for supplying gas comprising a pressure bottle adapted to be filled with a gas under pressure and an outlet valve which communicates with the interior of the bottle by way of a pressure reducing system; and wherein the pressure reducing system comprises alternately combined ducts and chambers, one of which ducts is an inlet duct for the gas and another of which ducts is an outlet duct communicating with the outlet valve to provide an expansion path for the gas from the inlet to the outlet ducts through the pressure reducing system, and the pressure reducing system is located in a receiving tube which is secured at one end to the chamber at the beginning of the expansion path and connected at the other end to the outlet valve of the bottle.

The effect of the pressure drop in this system of turbulence chambers and ducts is based on the Bernoulli law of continuity which is as follows:

$$\Delta P_1 - \Delta P_2 = \Delta P_{verl} = \frac{\gamma}{2g} \cdot (W_2^2 - W_1^2)$$

P_{verl} = the loss in pressure to be determined

P_2 = pressure of the medium after pressure release

P_1 = pressure of the in-going medium

γ = specific weight (specific gravity) of the medium

$2g$ = acceleration due to gravity ($g = 9.81$ m/sec²)

$\frac{\gamma}{2g}$ = density of the medium

W_1 = speed of the flowing medium before pressure release

W_2 = speed of the flowing medium after pressure release

The system of turbulence chambers and orifices uses the turbulence to intensify the effect of the pressure drop by the pressure loss attributable to the turbulence. It is possible for the gas to expand in the successive chambers. Thus, energy is taken from the surroundings in a stepwise manner by coupling a plurality of ducts and chambers to each other. This energy is returned to the

chambers through the receiving tube enclosing the chambers to reduce the possibility of ice forming in the shut-off valve, even at high outflow velocities. When the gas flows, through the chambers and ducts heat generated by molecular friction within the gas is returned to the chambers and ducts by way of the tube.

The arrangement of ducts and chambers is accommodated in a completely rigid and vibration-free manner in the tube connected to the valve of the bottle. This has the advantage that the arrangement of ducts, and chambers forms an assembly unit together with the tube.

In order to obtain a particularly advantageous expansion effect, and in accordance with a preferred feature of the invention, some of the chambers are of pear-shaped construction, while some of the chambers are of spherical construction. The pear-shaped chambers should be located at the beginning of the expansion path and the spherical chambers should be located at the end of the expansion path.

In accordance with a further preferred feature of the invention, there are four chambers, the last chamber having an outlet duct opening into the valve of the bottle. This results in particularly advantageous turbulence and thus expansion.

Considered as a whole, the advantages of the apparatus proposed by the invention reside in the fact that oxygen supply apparatus functions reliably without risk of mechanical faults, even for periods of time lasting for several hours, so that this apparatus is particularly suitable for clinical purposes. Consequently, the invention can be used in a system having coupled oxygen bottles. Tests have shown that the apparatus in accordance with the invention functions reliably both in tropical and in arctic conditions. Furthermore, apparatus provided with the described pressure reducing system can be refilled at any industrial oxygen plant. The receiving tube is conveniently made of copper.

The invention will be further described hereinafter by way of example, with reference to the accompanying drawing.

The drawing shows an oxygen bottle 10 in which oxygen under high pressure is contained. The oxygen bottle has an outlet shut-off valve 11, a manometer 12, and an outlet connection piece 13.

A pressure reducing system is located in the interior of the bottle 10 and comprises four chambers 1 to 4 arranged inside a copper receiving tube 5, which chambers are 11 mm in diameter and which are interconnected by respective ducts 6a, 6a, 6b, 6b, 6c. The first two chambers 1 and 2 are of pear-shaped configuration, and the two chambers 3 and 4 are spherical. The oxygen enters chamber 1 by way of a filter 8 and the inlet duct 6a which has an internal diameter of 0.20 mm, and enters the chamber 2 by way of the second duct 6a which has an internal diameter of 0.20 mm. Oxygen enters the spherical chamber 3 through the duct 6b having an internal diameter of 0.30 mm, and is fed to the spherical chamber 4 through a further duct 6b having an internal diameter of 0.30 mm. The outlet duct 6c of chamber 4 has an internal diameter of 0.40 mm and opens into the shut-off valve 11 from where the gas is fed, for example to a patient. The receiving tube 5 is tightly screwed to the shut-off valve 11 and the chamber 1 is connected to the receiving tube 5 by means of a soldered joint 7. The length of the receiving tube 5 is approximately 85 mm. The indicator manometer 12 is mounted on the shut-off valve 11 and permanently indicates the supply pressure of oxygen. The indicator manometer is under pressure even when the valve is closed.

WHAT WE CLAIM IS:—

1. Apparatus for supplying gas comprising a pressure bottle adapted to be filled with a gas under pressure and an outlet valve which communicates with the interior of the bottle by way of a pressure reducing system; and wherein the pressure reducing system comprises alternately combined ducts and chambers, one of which ducts is an inlet duct for the gas and another of which ducts is an outlet duct communicating with the outlet valve to provide an expansion path for the gas from the inlet to the outlet ducts through the pressure reducing system, and the pressure reducing system is located in a receiving tube which is secured at one end to the chamber at the beginning of the expansion path and connected at the other end to the outlet valve of the bottle.

2. Apparatus as claimed in claim 1, in which at least one chamber is of substantially pear-shaped configuration and has a diameter of substantially 11 mm.

3. Apparatus as claimed in claim 2 in which the or each pear-shaped chamber is located at the beginning of the expansion path adjacent the inlet duct.

4. Apparatus as claimed in claim 1 in which at least one chamber is substantially spherical and has a diameter of substantially 11 mm.

5. Apparatus as claimed in claim 4 in which the or each spherical chamber is located at the end of the expansion path adjacent the outlet duct.

6. Apparatus as claimed in any of the preceding claims in which each duct has an inside diameter equal to or less than that of the next adjacent duct in a direction towards the outlet valve.

7. Apparatus as claimed in any of the preceding claims in which the pressure reduc-

ing system comprises four chambers and five ducts alternately combined.

8. Apparatus as claimed in claim 7 in which the first and second ducts of the beginning of the expansion path have an internal diameter of 0.2 mm.

9. Apparatus as claimed in claim 7 or 8 in which the third and fourth ducts of the expansion path have an internal diameter of 0.30 mm.

10. Apparatus as claimed in claim 7, 8 or 9 in which the outlet duct has an internal diameter of 0.40 mm.

11. Apparatus as claimed in any of the preceding claims in which the receiving tube has a total length of approximately 85 mm.

12. Apparatus for supplying gas constructed and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

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1430213 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*